Coupled Subsurface-Surface-Atmosphere Feedbacks: Comparison of Two Coupled Modelling Platforms Applied to a Real Catchment

Rihani, J.; Larsen, Morten Andreas Dahl; Stisen, S.; Refsgaard, J.C.; Jensen, K. H.; Simmer, C.

Publication date:
2013

Coupled Subsurface-Surface-Atmosphere Feedbacks: Comparison of Two Coupled Modelling Platforms Applied to a Real Catchment

Rihani J[1], Larsen M[2], Stisen S[3], Refsgaard, JC[3], Jensen KH[2], Simmer C[1]

In recent years, a number of simulation platforms with varying complexity which couple groundwater, land surface, and atmospheric models have emerged. These platforms are designed to include processes affecting energy fluxes and soil moisture variations at the land surface such as shallow groundwater, overland flow, and subsurface lateral flow. Previous studies demonstrate the sensitivity of atmospheric boundary layer dynamics and precipitation to land surface energy fluxes and groundwater dynamics, as well as the importance of capturing these interactions through coupled models. This study compares two distributed, physically-based, state-of-the-art hydrological modelling platforms: The ParFlow-CLM-COSMO platform TerrSysMP (Terrestrial System Modelling Platform), developed within the Transregional Collaborative Research Centre 32 (TR32), and the HIRHAM-MIKE SHE platform developed within the HOBE Centre for Hydrology and the HYdrological Modelling for Assessing Climate Change Impacts at differeNT Scales (HYACINTS) project. Both platforms differ in the handling of subsurface processes in the unsaturated zone as well as in the coupling approach used. We focus in particular on the inclusion of lateral flow in the unsaturated zone. While both models use the 3D groundwater flow equation in the saturated subsurface region, MIKE SHE implements the 1D Richards' equation to simulate water flow in the unsaturated zone using simulated dynamic groundwater levels from its saturated zone module. ParFlow within TerrSysMP on the other hand includes lateral flows in the unsaturated zone by implementing the 3D Richards' equation for the entire subsurface region. Some of the main questions investigated by this work are: 1. Is the dynamic approach of including lateral flows in the unsaturated zone needed within real watersheds? 2. If so, at which locations and times does it become important? 3. How does lateral flow in the unsaturated zone affect location and effectiveness of zones of strongest coupling between water table depth and land surface energy fluxes, and subsequently atmospheric boundary layer formation and precipitation? The HOBE hydrologic observatory in Denmark, the Skjern catchment, is chosen for the simulations with both platforms. Previous studies done on the Skjern catchment indicate that a significant area of the catchment is groundwater-controlled with strong coupling to land surface processes, which makes it an ideal site for this comparison. The comparison study will highlight the effects and experiences of using different coupled modelling approaches on simulated subsurface-land surface-atmosphere interactions within a real hydrologic catchment.

[1] Meteorological Institute, University of Bonn, Germany
[2] University of Copenhagen, Denmark
[3] Geological Survey of Denmark and Greenland, Denmark

Rihani, Jehan jrihani@uni-bonn.de
Larsen, Morten Andreas Dahl ml@geo.ku.dk
Stisen, Simon sst@geus.dk
Refsgaard, Jens Christian jcr@geus.dk
Jensen, Karsten Høgh khj@geo.ku.dk
Simmer, Clemens (csimmer@uni-bonn.de)